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HD 305629, an Eccentric Ellipsoidal System

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The new variable star HD 305629, with a Cepheid-like light curve, is demonstrated, from our optical observations and ASAS-3 data, to actually be an ellipsoidal variable star on a highly eccentric orbit. It resembles the X-ray variable star BP Cru. HD 305629 deserves further observations in other wavelengths.

1 Introduction

During a systematic search of variable stars in the publicly available ASAS-3 database (Pojmanski 2002), apparent variability was found in the star HD 305629 ($10^{\rm h}51^{\rm m}34\overset{\rm s}{.}35$, $-60°47'57\overset{''}{.}4$, J2000.0; Fig. 1). The ASAS-3 light curve of the target is partially contaminated by HD 305630, a B1V star with $V = 10.62$, $B-V = 0.02$, and $J-K = -0.04$ lying $36''$ away. As a result of this, the scatter in the ASAS-3 observations is high. The light curve shape folded with a period of $51\overset{\rm d}{.}18$ showed a rapid rise to maximum and a slower decline which at first sight made us think of a bright long period classical Cepheid as a possible classification. However, the spectral type in the literature was B8 (Nesterov et al. 1995). The amplitude was also barely above $0\overset{\rm m}{.}1$ which is too low for such a type but that could be explained by the presence of a bright companion reducing the amplitude. The B8 spectrum could belong to that companion. Tycho-2 photometry converted to the UBV system using Bessell's tables (Bessell 2000) gives $V = 9.51$ and $B - V = 0.27$. 2MASS $J - K$ color is 0.25, which indicates reddening. After closer examination, a rapid drop in brightness right at the star's maximum peak was found, but the scatter in the light curve casted some doubts about its reality.

Since a Cepheid would be redder and would display color changes, BVR_cI_c photometry (see next section) was performed to check for the presence of those changes and also to determine accurate photometry for HD 305629 without the interference of the $36''$ companion.

2 Observations

All observations were carried out from December, 2011 to April, 2013 using a Meade 12-inch Schmidt–Cassegrain GPS telescope located at Carnes Hill Observatory. The camera used was an SBIG ST9 XE utilizing SBIG filter wheel and Custom Scientific BVR_cI_c photometric filters. Photometry was performed using AIP4WIN 2.0 with apertures carefully

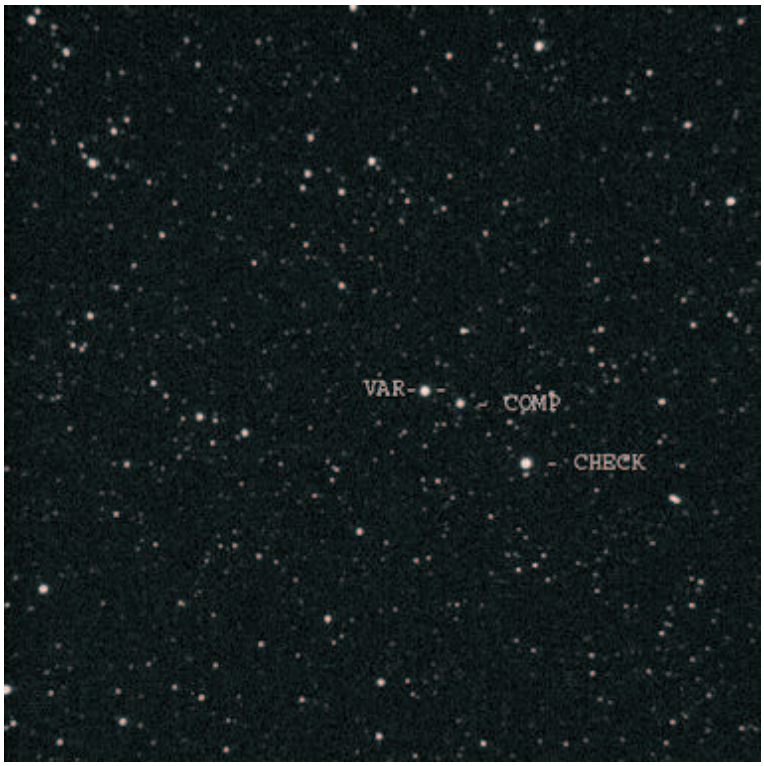

Figure 1.
Finding chart showing the variable and the comparison and check stars. North is up. The image scale is 1.″41/pixel. This ensured that appropriate apertures could be easily chosen to avoid any overlap with the comparison star.

selected to exclude surrounding stars. The same apertures were used for all measurements to ensure consistency. Magnitudes and colors are transformed to the standard system using Southern E-field stars E4103, E4106, and E4108. Corrections for primary and secondary extinction were applied in determining the magnitudes of the comparison and check stars. Plate solutions were obtained for the field using MPO Canopus software (version 9.3.1.0) to confirm the coordinates of each of the stars of interest. The comparison stars (identified in the finding chart in Fig. 1) used were:

Comp star = HD 305630; $10^{\rm h}51^{\rm m}29\overset{\rm s}{.}80$ $-60°48'10\overset{''}{.}4$ (J2000); $V = 10.620$; $B - V = 0.025$; $V - R_c = 0.062$; $R_c - I_c = 0.068$. Check star = TYC 8957-3762-1; $10^{\rm h}51^{\rm m}21\overset{\rm s}{.}51$ $-60°49'09\overset{''}{.}7$ (J2000); $V = 9.08$; $B - V = 1.38$; $V - R_c = 0.74$; $R_c - I_c = 0.65$.

3 Results

The light and color curves of HD 305629 from our observations are presented in Fig. 2.

After the V magnitude of our target was determined, we corrected the ASAS-3 dataset (http://www.astrouw.edu.pl/cgi-asas/asas_variable/105134-6048.0,asas3,51.183,3015.64,500,500) from the light contamination and the resulting difference in amplitude was only $0\overset{\rm m}{.}05$. The mean resulting colors were: $B - V = 0.26$; $V - R_c = 0.22$; $R_c - I_c = 0.27$; $V - I_c = 0.49$. The relatively faint R_c (9.34) and I_c (9.07) magnitudes indicated that the Cepheid plus B8 companion hypothesis was not possible. Also there were no color changes revealing pulsational behavior.

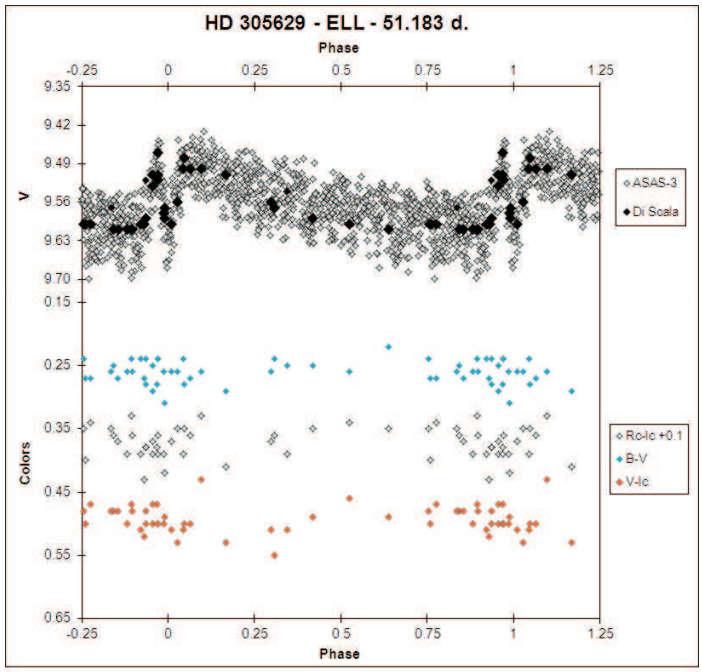

Figure 2.
The V light curve and color curves of HD 305629. No apparent color changes are seen which – together with the clear detection of the two different maxima and minima – rules out the Cepheid classification.

Combining our dataset with the ASAS-3 observations, we determined the light elements:

$$\text{Min} = 2453015.64 + 51\overset{\text{d}}{.}183 \times E.$$

The star varies between $V = 9.47$ and 9.61. The light curve in four colors is presented in Fig. 3. It confirms that the dip around maximum is real. This rules out the Cepheid classification, suggesting HD 305629 is a very eccentric binary system. Its light curve looks remarkably similar to those of the eccentric ellipsoidal red giants in the Large Magellanic Cloud (Soszynski et al. 2004). A first minimum is reached around orbital phase 0.91 followed by a gradual brightening that peaks at phase 0.97 and a rapid fading to reach another minimum at phase 0 and a new maximum at phase 0.04 (see Fig. 4).

Among B-type stars, we find one similar example in our Galaxy, the binary system BP Cru made up of a B2Ia supergiant and an X-ray pulsar in an eccentric $41\overset{\text{d}}{.}487$ orbit. This is an improved period for the system based on ASAS-3 and LTPV (Manfroid et al. 1991) data; see the light curve in Fig. 5. BP Cru undergoes X-ray outbursts just before periastron passage (Watson et al. 1982).

Observations of HD 305629 in other wavelengths are encouraged.

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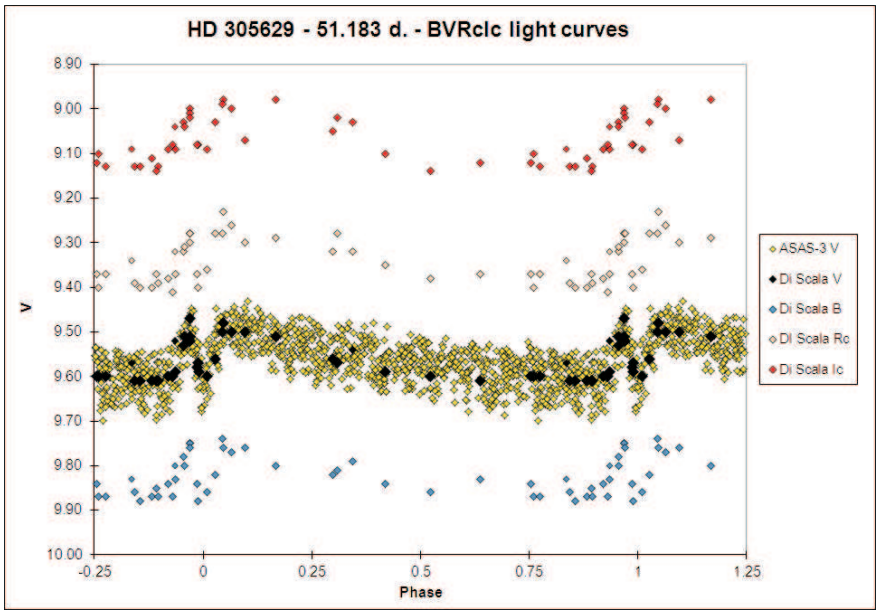

Figure 3.
Light curves in BVR_cI_c filters.

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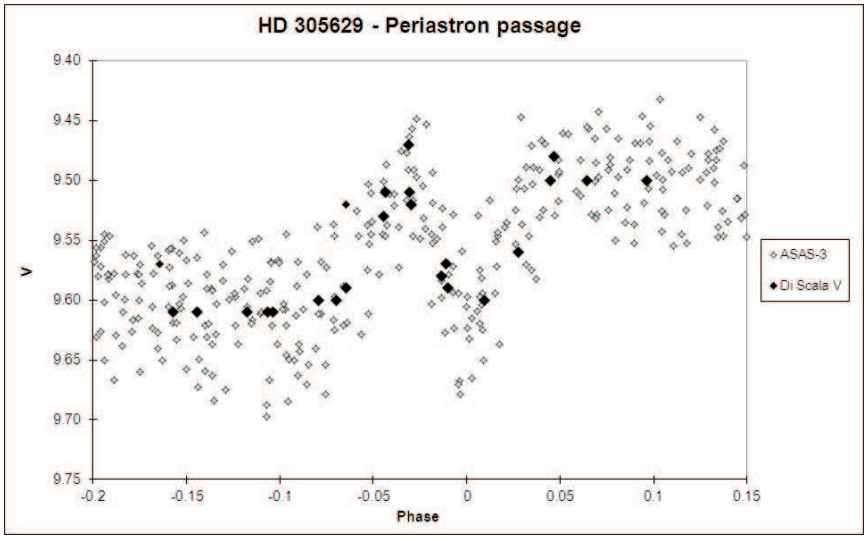

Figure 4.
A zoomed in portion of the light curve around periastron passage showing the two maxima and two minima.

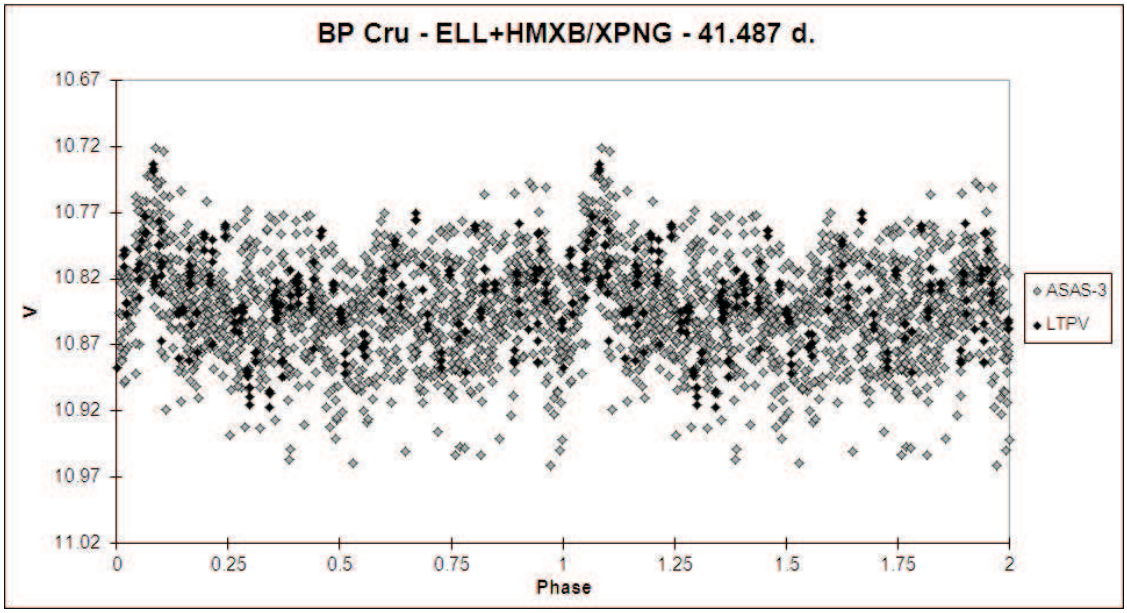

Figure 5.
Light curve of the ellipsoidal high mass X-ray binary BP Cru. The scatter in the phase plot is due to mean magnitude changes due to the binary interaction. The epoch of minimum is HJD 2445442.7.